



## **Alternative: Manage Storm Water from Short Duration Precipitation Events Using Catchment Basins in Urban Areas**

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### **1. Summary of the Alternative**

This white paper addresses increasing water supply in the Jemez y Sangre water planning region by capturing storm water flows in urban areas using catchment basins or other mechanisms such as roof harvesting. As discussed here, catchment basins refer to ephemeral reservoirs located on tributaries above the main stem of the local stream. Their intent is to moderate high flows resulting from short-duration precipitation events rather than to collect and store flows from longer-term seasonal variations in stream flows. The collected water is detained only briefly so that the basins are usually dry except for a period of one or two days after major precipitation events. In some cases a small permanent "water quality" pool is provided within the larger volume of the catchment basin to promote physical and biological treatment of storm water to meet water quality goals.

This white paper will consider four options:

- Use catchment basins to return infiltration/recharge to normal watershed rates (short-term retention).
- Use catchment basins to capture and divert surface waters (long-term "new" water supply).
- Harvest roof water for outdoor application simulating pre-dwelling conditions.
- Bank water (inject or infiltrate surface waters for retrieval at a later time).





These alternatives are designed to reduce flooding, enhance the natural recharge rate of downstream channels, and reduce demands for potable water for landscape irrigation. Their effectiveness is measured in additional acre-feet of water within the capture zones of water supply aquifers and reduction of irrigation demands on potable systems. Managing storm water in the Jemez y Sangre Water Planning Region will help protect the environment, protect the supply for existing demands, and improve the sustainability of the system. Because water rights are necessary for an increased diversion, this alternative is not expected to increase the supply available to meet the growing demand.

Urbanization of arid lands has numerous negative effects on natural hydrologic processes (Briggs, 1996; Riley, 1998) that are well understood. In the planning area such deleterious effects include:

- Major soil erosion from land and watercourse channels
- Significant impairment of surface water quality
- Increased flooding
- Reduction of natural infiltration rates
- Lowering of water tables
- Desiccation of aquatic and riparian habitat

The measures discussed here (Sections 1.1 through 1.4) in the context of water supply augmentation also mitigate some of these impacts, as discussed in Section 6.

### **1.1 Option 1: Short-Term Retention**

Urban watersheds with large impervious areas produce runoff with higher flow peaks and discharge more volume of water in a shorter time than runoff from the same land before it was developed. These urban “flash” floods may greatly exceed the infiltrative capacity of the downstream natural channels and result in erosion and other negative impacts on the stream. Numerous small detention ponds can be constructed in developed areas to reduce storm water runoff rates below the current “flashy” urbanized rates. The capturing of storm water in these ponds can increase infiltration from the bottoms of the detention ponds themselves as well as





downstream, where they discharge into existing sandy arroyos that are in communication with the local water supply aquifer. Outlets from these ponds should be designed with progressive discharge rates to control runoff from small as well as large storm events.

The net effect of properly designed detention ponds will be to decrease flood risk while increasing the duration of flow in the river after storms and increasing recharge. Detention ponds would be constructed in municipal drainage easements and would be maintained by the local municipality.

### **1.2 Option 2: Long-Term “New” Water Supply**

Catchment basins, as discussed here, are not ordinarily used to divert storm water from one watercourse to another. Such a diversion requires an Office of the State Engineer (OSE) permit, and in the permitting process, valid water rights and non-impairment of other water rights must be demonstrated. This option is considered in more detail in the white paper that discusses the construction of new large reservoirs (DBS&A, 2002b).

### **1.3 Option 3: Roof Water Harvesting**

Cisterns of one sort or another have long been used in arid areas to capture rainwater from roofs or other impervious areas for use during dry periods. Typically storage tanks are constructed below roof drains to capture runoff. The water is most often used to irrigate landscaping, thereby reducing the demand for potable irrigation water.

Cisterns have often been used historically for potable water supply as well. In this paper direct potable use of harvested roof water is not considered because (1) that involves additional measures to maintain water quality and (2) irrigation use is the larger demand. However, indirect potable use of roof and other urban runoff through groundwater recharge enhancement is accomplished by the other alternatives discussed here.





#### **1.4 Option 4: Surface Water Injection**

Banking of storm water is a broad concept that can be considered to be one of the goals of all of the options discussed in this paper. As discussed here, it means the transfer of urban storm water flow peaks into local groundwater. The methods to accomplish storm water banking can include engineered designs such as infiltration basins, galleries, in-stream infiltration check dams, and injection wells. Such recharge would provide opportunities for underground storage of the water to absorb differences between supply and demand for water, and to obtain soil-aquifer treatment benefits so that the water can be used for drinking. The detention basins would then also serve as pre-sedimentation basins to remove suspended solids and minimize clogging of infiltration systems for groundwater recharge. A detailed discussion of these alternatives is presented in a separate paper on aquifer storage and recovery (DBS&A, 2002a).

## **2. Technical Feasibility**

The detention basins described in Option 1 for recharge enhancement are different from traditional flood control detention ponds, which are used by most municipalities to attenuate large flows such as 100-year events. Thus most existing detention ponds in the Jemez y Sangre region have large outlets designed only to reduce major (100-year) flood peaks. However, much of the annual water comes in the form of routine, frequent storm flows (WEF and ASCE, 1992), which are routed undiminished through the detention ponds designed solely for 100-year flows. In many cases, it is feasible to modify the outlets of existing storm water detention ponds to moderate the flows from the more frequent small storms as well as large storms.

Sediment management is needed to periodically remove accumulated sediment from detention ponds and infiltration systems. Mechanical removal and disposal of sediment represents the main operational cost of detention basins. To minimize these costs it is prudent to employ erosion control best management practices in the watershed areas above the detention ponds.

It has been shown that detention ponds can be designed to enhance water quality as well as reduce flood peaks (Denver Urban Drainage and Flood Control District, 1992). Conventional





dry detention ponds can be very effective at capturing excess sediment in storm water. With the addition of small “water quality” pools, additional reduction of total suspended solids (TSS) and soluble pollutants can be achieved.

When choosing locations for detention ponds, it is necessary to identify favorable recharge reaches within the capture zone of existing or proposed supply wells. Those reaches would then be stabilized to maximize infiltration. Detention basins and infiltration check dams would typically be constructed within drainage easements and would be maintained by the local water supply entity.

Designs of infiltration basins vary with channel geometry and slope. Numerous low-height check dams (drop structures) can be constructed in degraded sections of the river and arroyo channels to reduce water velocity and increase infiltration. In addition, check dams reverse channel degradation by accumulating sediment that would otherwise be transported downstream.

Injection wells may be required where impermeable layers cause infiltrated water to perch above the local supply aquifer, as in the case of some Los Alamos sub basin streams. Injection wells are subject to physical clogging or chemical encrustation at the well screen and typically require some form of pretreatment. Therefore injection wells tend to be more costly than infiltration basins. They should be equipped with dedicated pumps to allow frequent short duration pumping to “backwash” clogging material. A variety of other types of infiltration systems, including storm water siphons and buried infiltration galleries, are being investigated by designers, but are not yet proven technologies. Where permeable alluvial fill with good infiltration characteristics exists, it is generally preferable to use surface infiltration basins due to their ease of maintenance as compared with subsurface systems. A more detailed discussion of methods for storing surface water is provided in a separate white paper on aquifer storage and recovery (DBS&A, 2002a).

Catchment facilities for roof harvesting of storm water are generally installed and maintained by property owners. The amount of water available for harvesting is a function of catchment surface (roof or pavement) area and weather. To effectively use the harvested water, the





storage volume must be adequate to balance inflow and irrigation uses. A storage volume in the range of 1,000 to 1,500 gallons per home is typically needed to optimize capture. Larger volumes are required to serve larger commercial or institutional water harvesting arrangements.

Roof harvesting of storm water is currently practiced by individual property owners in the planning region, using both aboveground and buried cistern tanks. Aboveground cisterns require no pump to water nearby landscaping. Underground tanks usually require a pump or sloped terrain plus piping to deliver the irrigation water to landscaping.

Rainwater harvesting systems can be constructed by individual homeowners in many cases. If the terrain permits, shallow earthen basins can make very inexpensive alternatives to cisterns. Landowners can plant trees, grass, and ornamental landscaping that otherwise would require irrigation directly in the basins. Infiltration pits with pumice wicks have also been successfully placed under individual roof spouts to promote infiltration and irrigate landscaping near the house.

Catchment water quality depends on dust and contaminants in roofing, pavement, or other contact surface. These potential pollutants are not of concern with irrigation use, but do make potable use of roof harvest water less feasible without treatment.

Closely related to the alternatives discussed above are land reclamation treatments employed on upland areas to reduce flooding and sediment discharges. Many years of research by the Natural Resource Conservation Service (NRCS) has shown that enhancing upland area vegetation and soils will reduce watershed curve numbers (runoff coefficients) and, as a result, make flood and sediment control easier. In the Jemez y Sangre planning region, land reclamation has been applied for wildfire recovery and agricultural purposes but has not been systematically employed in urban areas for flood and sediment control since the Civilian Conservation Corps (CCC) projects of the 1930s. In the Santa Fe area, however, hundreds of CCC rock check dams have endured without maintenance for more than 60 years and still provide valuable erosion control. Urbanization obviously has not stopped since the CCC programs were active, and large-scale land stabilization programs are needed now at least as much as they were in the 1930s.





In the context of water supply, the desired effect of land reclamation is to slow runoff and increase infiltration. Many watersheds in the planning area have been historically overgrazed or over-logged. Most Jemez y Sangre watersheds would benefit from land reclamation measures to increase the density of native grasses, promote infiltration, and control gully formation. Applicable reclamation measures are very site-specific but may include soil amendment, seeding, mulching, thinning of piñon-juniper stands, and construction of check dams to control gullies. Typical reclamation efforts include enhancement of native grass communities, construction of contour swales, and sediment reduction. These have been ordinarily employed as a means of reducing erosion for grazing improvements or environmental goals, but are also applicable for managing water and sediment in recharge systems and for flood control. Additional discussion of land management is presented in the white paper on forest management (DBS&A, 2002c).

### **3. Financial Feasibility**

For new construction, the cost of detention ponds and related in-stream facilities such as infiltration basins and check dams would probably be paid by developers if these facilities are required by local ordinance. Where communities already require storm water detention for flood control, the additional requirement to design and construct low-flow outlets and downstream infiltration measures would be relatively minor additions to storm water management costs already borne by developers or local government. Since the 1970s, Santa Fe terrain management regulations have required detention designed to reduce 100-year storms. However, the regulations have not been consistently enforced, and many areas developed since the 1970s still lack significant detention storage.

The main operational cost of detention basins would be for sediment management to periodically remove accumulated sediment from detention ponds and infiltration systems. These costs can be minimized by implementing erosion control best management practices in the watershed areas above the detention ponds.

For roof water harvesting, the cistern tank is typically the most expensive component of the system and costs on the order of \$1 per gallon of storage. If landscaping within a shallow





earthen basin is feasible, the storage and distribution costs are essentially eliminated. Roof water harvesting is generally feasible for homeowners and may easily be implemented with new development. However, government subsidies, regulatory requirements, or water rate incentives may be necessary to encourage retrofitting existing development for water harvesting.

Costs for banking water are discussed in a separate white paper (DBS&A, 2002a).

## 4. Legal Feasibility

### 4.1 Option 1: Short-Term Retention

Dams are regulated by the State Engineer (NMSA §72-5-32). Before constructing most dams, one must obtain a permit from the State Engineer (and meet the statutory criteria, that is, not cause impairment of any existing water rights, not be detrimental to the public welfare, and not be contrary to the conservation of water) (NMSA §72-5-6). Dams that are exempted from State Engineer permitting are stock dams, “erosion control structures whose maximum storage capacity does not exceed ten acre-feet,” and “dam[s] constructed for the sole purpose of sediment and flood control under the supervision of the United States army corps of engineers.” (Until 1997, no dams that were less than 10 feet in height and that impounded less than 10 acre-feet were subject to State Engineer regulation. In 1997, the legislature amended §72-5-32 to greatly restrict that exemption). The State Engineer’s primary concern in reviewing catchment dam applications would be to be sure that such dams do not increase net depletions to the surface water-groundwater system by increasing evapotranspiration. The State Engineer would likely require that any net depletions be offset by acquiring and retiring an equivalent amount of water rights.

Structures such as swales that do not completely dam a watercourse (defined in the State Water Code as “any river, creek, arroyo, canyon, draw or wash, or any other channel having definite banks and bed with visible evidence of the occasional flow of water” [NMSA 1978, §72-1-1) but merely slow down the water flow would not be considered “dams” and thus would not be subject to State Engineer permitting requirements.







(Unlike some other states, New Mexico does not define “dam” in the State Water Code or State Engineer regulations. One definition used by the U.S. Department of Agriculture is “an artificial barrier, with any associated spillways and appurtenant works, that does or may impound or divert water” [USDA Directive 650.1, Dam Safety (1980)]. Another definition that has been used in the Clean Water Act (CWA) context is “any structure which impounds waters” [NWF v. Gorsuch, 530 F. Supp. 1291 (D.D.C. 1982)]. Swales or other structures that only partially block or slow down water flows would not meet either of these definitions, as long as they do not have the capability of impounding water.)

The CWA also comes into play for catchment basins. Dams or dikes or any diversions that are constructed in arroyos or streams, which are considered “waters of the United States,” are subject to CWA jurisdiction and will require a permit from the Army Corps of Engineers under §404 (33 U.S.C. §1344). The bigger the land disturbance, the more onerous the permit conditions will be. At the same time, for municipalities and others that must obtain National Pollutant Discharge Elimination System (NPDES) permits from the U.S. Environmental Protection Agency (EPA) under the CWA for their storm water discharges (33 U.S.C. §1342(p)), EPA will be looking favorably on catchment systems that slow down and reduce pollution in storm water discharge.

#### **4.2 Option 3: Roof Water Harvesting**

Nothing in the State Water Code prevents individuals from harvesting runoff from roofs or property. Surface water does not become public and subject to State Engineer permitting until it enters a natural stream or watercourse (§72-5-27). Local governments are free to regulate and/or encourage this type of water management (see Section 4.1 in relation to harvesting water from property, where construction of dikes, swales, and/or dams is involved. Like catchment basins, from a CWA perspective, roof or property water harvest systems generally would improve storm water runoff quality and thus help compliance with the CWA.





#### **4.3 Option 4: Surface Water Injection**

For the legal feasibility of storing harvested water aboveground, see Section 4.1. Until the Ground Water Storage and Recovery Act (§72-5A-1 *et seq.*) was enacted in 1999, it was not possible to store water underground without it becoming public water subject to appropriation. Of course, simply increasing underground water supplies, without permitting and private ownership of the increased water, may be sufficient to meet the region's goals. In addition, however, water may be stored underground just as it may be stored aboveground, upon compliance with the Ground Water Storage and Recovery Act and after obtaining a permit from the State Engineer.

### **5. Effectiveness in Either Increasing the Available Supply or Reducing the Projected Demand**

The yield available from enhancement of recharge in urbanized areas is dependent on a number of site-specific characteristics, especially the connected impervious area and characteristics of the receiving channel. Recent stream gaging data for the urbanized reach of the Santa Fe River provides an empirical basis to estimate yield for that system as an example of potential yields available from these measures.

The watershed of the Arroyo Mascaras is urbanized, relatively steep, and severely affected by erosion. Large impervious areas, including the De Vargas shopping mall, discharge through the arroyo to the Santa Fe River without any significant detention storage that mitigates flooding. The bulk of the annual discharge at this location comes in the form of summer thunderstorm events. A flood modeling study estimated the 100-year discharge rate for the Arroyo Mascaras at its confluence with the Santa Fe River to be 2,488 cubic feet per second (cfs) (Bohannon Huston, 1993). During summer thunderstorms it is very common for flood peaks of several hundred cfs or more to flow from the Arroyo Mascaras into the Santa Fe River.

The existing Santa Fe City well field is distributed in the urban area generally west of St Francis Drive and downstream of the Arroyo Mascaras confluence. A number of studies have shown





that the Santa Fe River has very high natural infiltration rates west of St Francis (DE&S, 2001), and this reach is thus an active recharge zone for the aquifer serving the City wells.

A current study is measuring the interaction of the stream and the alluvial aquifer serving the City wells (DBS&A and Watershed West, 2002). Records from a stream gage installed in 1998 on the Santa Fe River at Ricardo Road indicate that this reach is strongly affected by urbanization, with large surges of runoff in response to summer rainfall. During dry weather, surface flows in the upper reaches of the river infiltrate into the sandy channel rapidly, usually considerably above the Ricardo Road gage. However, storm flows from the Arroyo Mascaras frequently overwhelm the infiltrative capacity of the wide sandy receiving channel and produce flashy peaks at the Ricardo Road gage.

In water year 1999 approximately 207 acre-feet flowed past the Ricardo Road gage (Ortiz and Lange, 2001). Complete records are not available for water year 2000. In water year 2001 the recorded discharge was approximately 184 acre-feet (DBS&A and Watershed West, 2002). Examination of the gage records indicates that the bulk of this water came during summer rainfall events.

The location of the Ricardo Road gage is near the downstream margin of the capture zone for the City well field. Large flows that surge past this gage are essentially lost to the well field, although they do contribute to recharge downstream. If flood peaks were attenuated by detention basins placed upstream (for example, in the Arroyo Mascaras basin), much more of the flow would infiltrate to the aquifer before reaching the Ricardo Road gage. Thus the Ricardo Road annual flows provide a very rough estimate that effective management of the tributary arroyo storm flows could result in additional recharge to the City well field of approximately 200 acre-feet per year, more in years with wet summers.

The yield available from roof water harvesting depends on the impervious area which is used as well as the capacity of the individual storage tanks or ponds. A 1,500-square-foot roof area in Los Alamos could yield a total of about 7,500 gallons of water during a typical summer with 8 inches of precipitation. Assuming that approximately 7,000 homes harvested runoff in Los Alamos, this source could supply approximately 160 additional acre-feet per year. For Santa





Fe, with 6 inches of precipitation during a typical summer (DE&S, 2001), the annual harvest would be about 5,600 gallons for a 1,500-square-foot roof area. Assuming that approximately 24,000 homes in Santa Fe (or an equivalent area of commercial development) harvested runoff, this source could supply approximately 410 additional acre-feet per year.

## **6. Environmental Implications**

The options discussed here will generally have positive environmental impacts. The measures will increase recharge and contribute to raising local water tables, while decreasing peak rates of runoff and flood risk in urban areas. The measures discussed here also contribute to river restoration action strategies by improving surface water quality, reducing channel erosion, and contributing to ecologically healthy streams. To the extent that these measures stabilize and increase soil moisture in riparian areas, they also improve native aquatic and riparian wildlife habitat.

If captured storm flows will infiltrate or be injected into the subsurface, however, it is important to identify chemical or radiological contamination that may be present in the recharge zones. If recharge basins are placed over contaminated sites, transport of contaminants can be accelerated. This potential may limit the application of methods to enhance recharge in some areas, including some canyons draining Los Alamos National Laboratory.

The effect of increased recharge on downstream communities should also be considered, although increased upstream groundwater storage is generally considered beneficial to downstream communities. In the planning region, increased upstream recharge is not judged to be detrimental to downstream users. However, available streamflow for downstream water right owners may be reduced depending on how catchment basins are managed, how this “new” water is legally recognized, and to how and to where it is conveyed.

## **7. Socioeconomic Impacts**

The Jemez y Sangre region of northern New Mexico is distinguished by its rural and agricultural character, predominantly Indian and Hispano population, localized land-based economies, and





pockets of persistent poverty. In particular, its Indian and Hispano populations represent some of the most unique cultures in the world, products of a long history of continuous human habitation, adaptation, and cultural blending. Land-based Indian and Hispano cultures still thrive, carrying on centuries-old cultural traditions that include distinctive land-use and settlement patterns, agricultural and irrigation practices, natural resource stewardship practices, social relations, religious activities, and architecture. An example is the ancient acequia tradition, which is vital both as a sustainable irrigation system for subsistence and market agriculture and as part of the social glue that holds together rural communities.

The survival of these deeply rooted local traditions is essential for the continuity of rural culture and communities and, in turn, for the local tourism industry, which is built in large part upon the singular cultural and historical personality of the region. Preservation of these traditions is therefore an important consideration in determining the socioeconomic and cultural impacts of regional water planning.

All four options discussed herein for managing storm water using catchment basins in urban areas would have no significant direct socioeconomic or cultural impacts. By making more water available to more populous urban areas, this alternative would have the primary indirect socioeconomic and cultural benefit of reducing the desire for and pressure on upstream rural and agricultural surface water rights to support municipal and industrial needs. A possible detrimental impact that must be carefully considered, depending on how catchment basins are managed and how any “new” water is legally recognized, might be a reduction of available streamflow for downstream water right owners.

Other indirect benefits would include the aesthetics of more vegetation and greater opportunities for personal or community gardens from the outdoor application of rooftop harvesting. In general, increasing available water would probably reduce the cost for all water users.

## **8. Actions Needed to Implement/Ease of Implementation**

Municipalities should conduct a thorough review of drainage in urban areas to identify recharge areas for their supply wells and feasible locations for detention ponds, infiltration basins, or in-





stream measures. In many cases existing detention ponds can be upgraded at modest cost with the addition of low-flow outlets. In addition, opportunities often exist to convert culverted road crossings into low-flow detention ponds. Check dams and in-stream measures to increase infiltration in natural channels should be designed and constructed in accordance with local river corridor master plans where they exist.

Infiltration enhancement, watershed reclamation, and sediment management should be considered integral components of local water supply programs and should be funded as such. Major detention and recharge facilities, in particular, should be operated by a public entity. Drainage easements should be defined to permit ongoing maintenance of the facilities. Municipalities should develop formal goals for aquifer recharge enhancement and monitor the effectiveness of the measures adopted through stream gaging and groundwater studies.

Residents and business should be encouraged or required by ordinance to harvest roof water, to the extent practical, prior to discharge of runoff to the municipal drainage network. Land owners would build and maintain the roof water harvesting tanks or ponds according to requirements of the municipality. In 2001 Santa Fe adopted a landscape site design ordinance that offers incentives for water harvesting, and an amendment is currently under consideration that would require installation of water harvesting tanks for all new development except within the Business Capitol District.

Land reclamation measures need to be organized with the consent and cooperation of landowners and developers. An initial step is to formalize municipal planning goals that embody water supply objectives to justify future regulatory requirements on development.

## **9. Summary of Advantages and Disadvantages**

Apart from increasing available local water resources, urbanized areas within the planning area generally need flashy runoff reduction, erosion control, and water quality improvement. Urban riparian areas also generally require channel stabilization and protection of recharge zones.

These measures also can be designed to significantly:





- Reduce peak rates of flow for urban flood reduction
- Raise the local water table to revive desiccated riparian bosques
- Convert ephemeral reaches to perennially flowing reaches
- Increase the usable volume of groundwater for drought protection
- Reduce channel erosion and restore degraded urban arroyo channels
- Improve storm water runoff quality
- Achieve river restoration goals for improving aquatic and riparian habitat

No adverse effects of these programs are anticipated. But to achieve the desired improvement, the water supply and environmental goals for these measures must be clearly stated and required by local engineering, planning, and land use ordinances.

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